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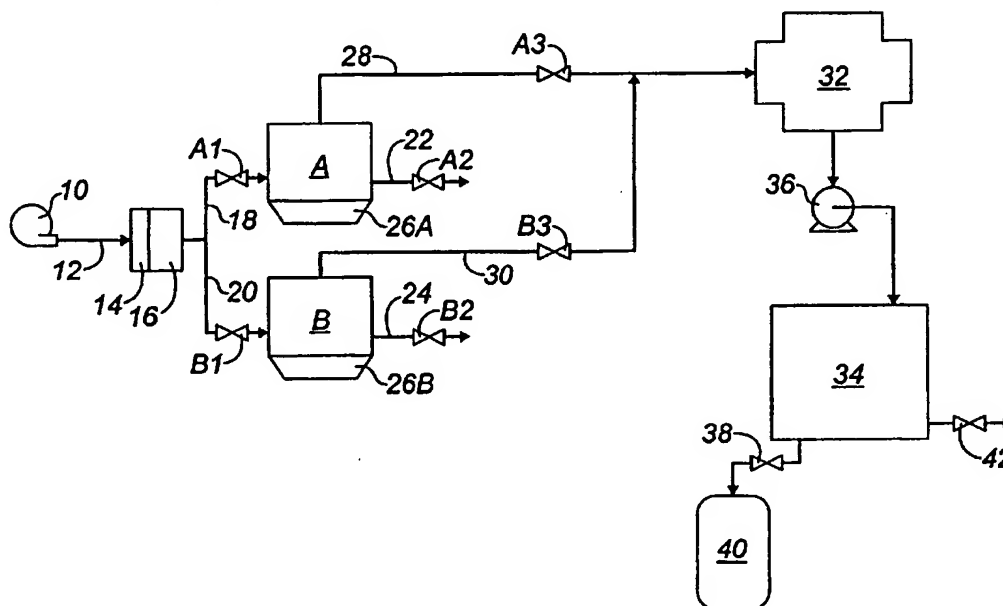
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(54) Title: METHOD AND APPARATUS FOR PRODUCING POTABLE DRINKING WATER FROM AIR



(57) Abstract: A system for producing potable water from air includes a bed of a sorption material which captures humidity from the atmosphere, means for displacing air through the sorption bed, means for heating the sorption bed to drive off water vapour, and a condensation chamber for condensing the water vapour.

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5 **METHOD AND APPARATUS FOR PRODUCING POTABLE
DRINKING WATER FROM AIR**

FIELD OF THE INVENTION

10 The present invention relates to production of potable water by capturing
and releasing water vapour with a sorption material.

BACKGROUND OF THE INVENTION

15 Fresh potable water is not always available in remote areas and must be
delivered by container. It is well known that a number of materials absorb water
from air. At room or normal atmospheric temperatures and pressure, materials
such as zeolites, silica gel, activated alumina, copper sulfate, and numerous other
materials all absorb or adsorb water. If such materials are heated to a certain
20 temperature, the water will be driven from the materials as steam or water vapor.

 Therefore, there is a need in the art for a method and apparatus of
producing potable water by taking advantage of the properties of such sorption
materials.

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SUMMARY OF THE INVENTION

 To provide water that has minimal contamination from typical surface
water contaminants, the physical sorption of water by a sorption material may be
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harnessed to produce potable water. The methods and apparatuses of the present invention allow the production of potable water from atmospheric water vapour, otherwise referred to as humidity. Even air in the driest of deserts has water (humidity) that can be used to produce potable water for drinking.

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In one aspect of the invention, the invention comprises a method of producing potable water comprising the steps of:

- 10 (a) drawing or forcing moist air through a sorption bed thereby dessicating the air;
- (b) heating the sorption bed to drive off water which has been absorbed and/or adsorbed into the sorption bed;
- 15 (c) condensing the water vapour from step (b);
- (d) collecting the water from step (c).

The method may further comprise the step of disinfecting the water collected. In
20 one embodiment, at least two sorption beds are provided wherein one sorption bed is absorbing water at the same time the other sorption bed is being heated.

In another aspect, the invention comprises an apparatus for producing
potable water comprising: a bed of sorption material; means for displacing air
25 through the sorption bed; means for heating the sorption bed to drive off water vapour; and a condensation chamber for capturing and condensing water vapour driven from the sorption bed. In one embodiment, the apparatus comprises at least two sorption beds which may be operated in parallel. There may be

diversion means for directing the air from the fan through one sorption bed to the exclusion of the other sorption bed or beds.

5 The condensation chamber may comprises a cooling element using active refrigeration or may rely on air cooling. The apparatus may further comprise a water storage chamber and means for drawing water from the condensation chamber to the storage chamber.

10 In one embodiment, the apparatus may further comprise disinfection means for disinfecting the water either in the condensation chamber or the storage chamber. The disinfection means may comprise an ozone trickler or a source of UV radiation, or other well-known disinfection strategies.

15 In different embodiments, the heating means may comprise electric heating elements dispersed within the sorption bed, a source of combustion, solar reflectors, or a closed fluid recirculation system comprising a pump, a fluid heater and a plurality of heat tubes passing through the sorption bed. Other well-known means of heating a bed of sorption materials may be implemented.

20 **BRIEF DESCRIPTION OF THE DRAWINGS**

The invention will now be described by way of an exemplary embodiment with reference to the accompanying drawing:

25 Figure 1 is a schematic depiction of one embodiment of the apparatus of the present invention.

Figure 2 is a depiction of one embodiment of the invention, incorporating electric heating and a hood and chimney.

5 Figure 3 is a depiction of another embodiment, incorporating electric heating.

Figure 4 is a depiction of another embodiment, incorporating direct combustion heat.

10 Figure 5 is a depiction of another embodiment, incorporating solar heating.

Figure 6 is a depiction of another embodiment, incorporating a closed fluid recirculation heating and cooling system.

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DETAILED DESCRIPTION OF THE INVENTION

The present invention provides for methods and apparatuses for producing potable water. When describing the present invention, the following terms have the following meanings, unless indicated otherwise. All terms not defined herein have their common art-recognized meanings.

25 The term "sorption material" refers to material which will absorb or adsorb atmospheric water vapour at ambient temperatures (about -40° to about 45° C) and pressures of 0.5 bar to 10.0 bar. Suitable sorption materials include but are not limited to zeolites, silica gel, activated alumina, and copper sulfate. The term "sorption" refers the processes of absorption and adsorption occurring jointly or separately.

Figure 1 shows a schematic diagram of one embodiment of the system. Preferably, the system works continuously by having two or more sorption beds. One sorption bed is giving off drinking water while the second bed is absorbing drinking water from the air. A fan is used to force air through the beds while they are absorbing water from the air. As a result only one fan is required which works continuously. Air diverting plates may be manipulated to alternatively direct air to a sorption bed. To remove water from the sorption beds they must be heated. One heater for each of the sorption beds is provided. When air is not passing through the sorption beds, they may be heated to about 200° C (400° F) or higher. The high temperature forces the water out in vapor form and the water vapor is then condensed. The condensed water once cooled is ready for consumption as drinking water and may be sterilized or disinfected as required.

To increase the potability of the water, the incoming air is filtered to remove dust and any volatile organic compounds (VOCs). These filters are standard and well known. They may include porous materials such as cotton fibers, cellulose fibers, synthetic fibers of numerous types and tailored for requirements, activated charcoal, and specialized zeolites. Particles are removed by the fiber filter and VOCs and other pollutants such as NO₂ and SO₂ by the tailored activated charcoal filter or the specialized zeolites. The air passes through these filters before it enters the sorption beds where the water is removed from the air by the sorption material in beds 'A' and 'B', as shown in Figure 1.

Once the water that is forced from the beds by heat is condensed it goes to the water reservoir where it may be maintained fresh and potable by feeding in small amounts of ozone or other disinfectants. The ozone assists in maintaining a disease free and fresh tasting water at all times. Other well-known disinfecting

means may be used, such as UV irradiation.

With reference to Figure 1, the air fan (10) sucks air in and forces the air through pipe (12) where it is first forced through the fiber filter (14) and then
5 through the charcoal filter (16). The filters remove any particles in the air along with any volatile organic compounds (VOC's) or other pollutants. As the air comes out of the filters it goes down pipe (18) or (20) depending on which sorption bed is removing water from the air and which is regenerating. If Bed 'A' is removing water and Bed 'B' is regenerating, then valves A1, A2, and B3 are
10 open and valves B1, B2, and A3 are closed. Since Bed 'A' is removing moisture from the air, the air from the filters passes down pipe (18) and through open valve A1 and into sorption bed 'A' where the water in the air is removed and the air then continues on through pipe (22) and valve A2. The air originating from fan (10) continues passing through sorption bed 'A' until it is saturated with water.
15 The sorption beds may be designed so that the time to saturate the sorption bed with water from the air coincides with the amount of time required to regenerate the other bed that in this case is sorption bed 'B'. In one embodiment, the sorption beds comprise 3A molecular sieve zeolite as the sorption material. Of course, other sorption materials may be used.

20

Once sorption bed 'A' is saturated, valves A1, A2, and B3 are closed and valves B1, B2, and A3 are opened. All valves may switch at the same time. The air from fan (10) then passes through the filters (14, 16) and pipe (20) and through
valve B1 and into sorption bed 'B' which then starts removing water from the air
25 and then through pipe (24) and valve B2. Heater (26A) is turned on to heat sorption bed 'A'. The range of temperature can be between 350° F to 550° F. The actual operating temperature will depend on air humidity and the amount of water one wishes to produce from the sorption beds in a given time. The

temperature of regeneration of the sorption beds may be adjustable.

As the temperature rises on sorption bed 'A' the water will come off the bed as a vapour and be forced down pipe (28) and through valve A3 and into
5 condenser (32). The condenser may operate from a refrigerant coil, cooling air, water, heat pipe or other heat sink material, as is well known in the art. Once the water is condensed it will be sucked or pumped into the water storage vessel (34) by means of vacuum or pump (36). Once the water is in storage vessel (34) a small amount of ozone or other disinfectant may be added to the water through
10 valve (38) from storage tank (40) to provide fresh tasting water substantially free of pathogens. Finally, a water outlet valve (42) is provided.

Once sorption bed 'A' is dry, heater (26a) is turned off and sorption bed 'A' is cooled to be ready to receive air again from fan (10). Once sorption bed
15 'A' is cooled, valves B1, B2, and A3 are closed and valves A1, A2, and B3 are opened. At the same time heater (26b) is turned on to start the regeneration of sorption bed 'B', water vapour is driven through pipe (30) and air starts to flow through sorption bed 'A' where it starts to remove water from the air. The air again is coming from fan (10) through the filters and pipe (18) and out pipe (22)
20 after leaving its water in sorption bed 'A'.

Similar to sorption bed 'A', sorption bed 'B' is heated to drive its water off using heater (26B). As with sorption bed 'A', sorption bed 'B' has its water forced out of the bed and down pipe (30) and into condenser (32) where the water
25 is condensed. As with the water from sorption bed 'A' the water from sorption bed 'B' is sucked or pumped from the condenser into the water storage vessel. Once the water is in the vessel, a small amount of ozone may be added to guarantee fresh tasting water free of pathogens.

Cycling of the sorption beds may continue indefinitely, thereby continuously producing potable water.

5 Figure 2 depicts an alternative embodiment of an apparatus as relates to one sorption units required for continuous production of potable water. The apparatus depicted in Figure 2 uses electrical heating to drive water from the sorption bed (200). The fan (210) at the bottom is used to push air through the sorption bed (200), the chimney (222) and through the butterfly valve (220). The
10 chimney (220) will assist the fan (210) in pulling air through the sorption bed (200). Filters are just after the fan to remove any undesirable vapours or dust from the air. A charcoal filter (216) and a fiber filter (214) are used as described above and zeolite materials (218) are used in selective filtering. The apparatus has a canopy (212) about it to create a chimney effect to assist in cooling the bed once
15 it has been dehydrated. Plates (224) to catch condensate that forms on the inside of the chimney (222) drain down to a water filter (228) and into water storage (230) that has a small ozone generator (232) or ultra-violet light. Electrical heating elements (226) are dispersed in the sorption bed (200) to heat the bed in order to drive off water vapour.

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 Figure 3 is another example of the invention involving a single sorption unit using electrical heaters and a single fan and one butterfly valve. The sorption cycle starts by blowing air through filters (314) with fan (310). The filtered air passes through sorption bed (300) which may be filled with zeolites or other
25 sorption material and the dried air then passes through hood (322) and through butterfly valve (320) and back into the atmosphere. Once the sorption bed is saturated, butterfly valve (320) is closed and electrical heaters (326) are turned on which are electrically supplied through electrical supply (327). Because of the

packing bed warming air rises through chimney (328) which helps condense water driven off bed (300) by the electrical heaters (326) into the area marked (330) where it then goes to the hood surface (322) which is cooled by the passing air. The water is collected by plates (324) and runs through water filter (332) and then
5 into tank (334). The ultraviolet light (336) is one option to keep the water fresh.

Figure 4 illustrates one embodiment of an apparatus that uses direct combustion heat to drive the water from the sorption bed once it is saturated. A heat chamber (402) which contains a combustion source (404) surrounds the
10 sorption bed (400). A separate combustion chimney (406) vents the products of combustion to the atmosphere. Heat distributing elements (412) may be dispersed in the sorption bed to conduct heat into the bed from the heat chamber (402). The heat distribution elements (412) may be formed from heat conducting materials such as copper rods or rods or pipes of other conducting materials. The fan (410)
15 and air filter (414) are provided as in other embodiments. The fan (410) is turned off when the combustion heat is on and vice-versa. The chimney butterfly valve (420) is closed when the heat was on and the condensing tube butterfly valve (422) would be open to take vapour driven off the bed and condense it by air cooling on the condenser tube (424). Active cooling using refrigerant methods
20 may also be employed. This embodiment of a unit includes a water filter (426) which is optional on any embodiment of the invention. When the water is driven off the sorption bed the combustion heat is stopped and the fan is turned on with the chimney butterfly valve open and the condensing butterfly valve closed.

25 Figure 5 illustrates an alternative embodiment of the apparatus that is powered by solar power. The sorption bed (500) is heated by solar reflectors (502) that focus on the sides of the sorption bed shell (504) and the heat is conducted into the bed through heat conductors (506) that go horizontally across

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20 may also be employed. This embodiment of a unit includes a water filter (426) which is optional on any embodiment of the invention. When the water is driven off the sorption bed the combustion heat is stopped and the fan is turned on with the chimney butterfly valve open and the condensing butterfly valve closed.

25 Figure 5 illustrates an alternative embodiment of the apparatus that is powered by solar power. The sorption bed (500) is heated by solar reflectors (502) that focus on the sides of the sorption bed shell (504) and the heat is conducted into the bed through heat conductors (506) that go horizontally across

As will be apparent to those skilled in the art, various modifications, adaptations and variations of the foregoing specific disclosure can be made without departing from the scope of the invention claimed herein.

WHAT IS CLAIMED IS:

1. An apparatus for producing potable water comprising:
5
 - (a) a bed of sorption material;
 - (b) means for displacing air through the sorption bed;
 - 10 (c) means for heating the sorption bed to drive off water vapour; and
 - (d) a condensation chamber for capturing and condensing water vapour driven from the sorption bed.
- 15 2. The apparatus of claim 1 comprising at least two sorption beds which may be operated in parallel.
3. The apparatus of claim 2 further comprising diversion means for directing the air from the fan through one sorption bed to the exclusion of the other
20 sorption bed or beds.
4. The apparatus of claim 1 wherein the condensation chamber comprises a cooling element.
- 25 5. The apparatus of claim 1 further comprising a water storage chamber and means for drawing water from the condensation chamber to the storage chamber.

6. The apparatus of claim 5 further comprising disinfection means for disinfecting the water either in the condensation chamber or the storage chamber.
- 5 7. The apparatus of claim 6 wherein the disinfection means comprises an ozone trickler.
8. The apparatus of claim 6 wherein the disinfection means comprises a source of UV radiation.
- 10 9. The apparatus of claim 1 wherein the condensation chamber comprises a hood and chimney disposed above the sorption bed and collection plate which is attached to an interior surface of the hood, wherein water vapour may condense on the interior surface of the hood and chimney and collect on the collection plate.
- 15 10. The apparatus of claim 1 wherein the heating means comprises electric heating elements.
- 20 11. The apparatus of claim 10 wherein the electric heating elements are dispersed within the sorption bed.
12. The apparatus of claim 1 wherein the heating means comprises a source of combustion.
- 25 13. The apparatus of claim 12 further comprising heat conducting elements dispersed within the sorption bed for conducting heat from the source of combustion to the sorption bed.

14. The apparatus of claim 1 wherein the heating means comprises solar reflectors.
- 5 15. The apparatus of claim 14 further comprising heat conducting elements dispersed within the sorption bed for conducting heat from the solar reflectors to the sorption bed.
- 10 16. The apparatus of claim 1 wherein the heating means comprises a closed fluid recirculation system comprising a pump, a fluid heater and a plurality of heat tubes passing through the sorption bed.
17. A method of producing potable water comprising the steps of:
- 15 (a) drawing or forcing moist air through a sorption bed thereby dessicating the air;
- (b) heating the sorption bed to drive off water which has been absorbed and/or adsorbed into the sorption bed;
- 20 (c) condensing the water vapour from step (b);
- (d) collecting the water from step (c).
- 25 18. The method of claim 17 further comprising the step of disinfecting the water collected.

19. The method of claim 17 wherein at least two sorption bed are provided wherein one sorption bed is absorbing water at the same time the other sorption bed is being heated.

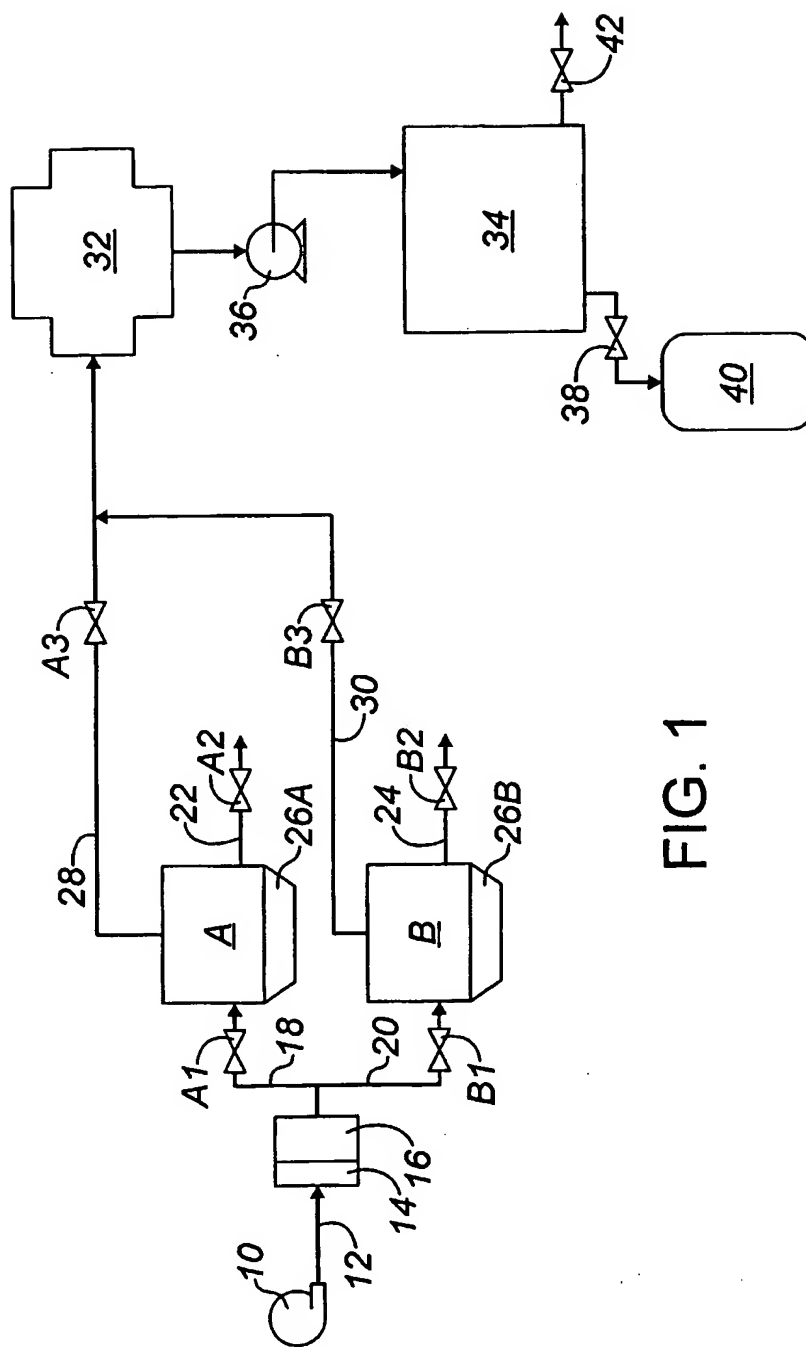
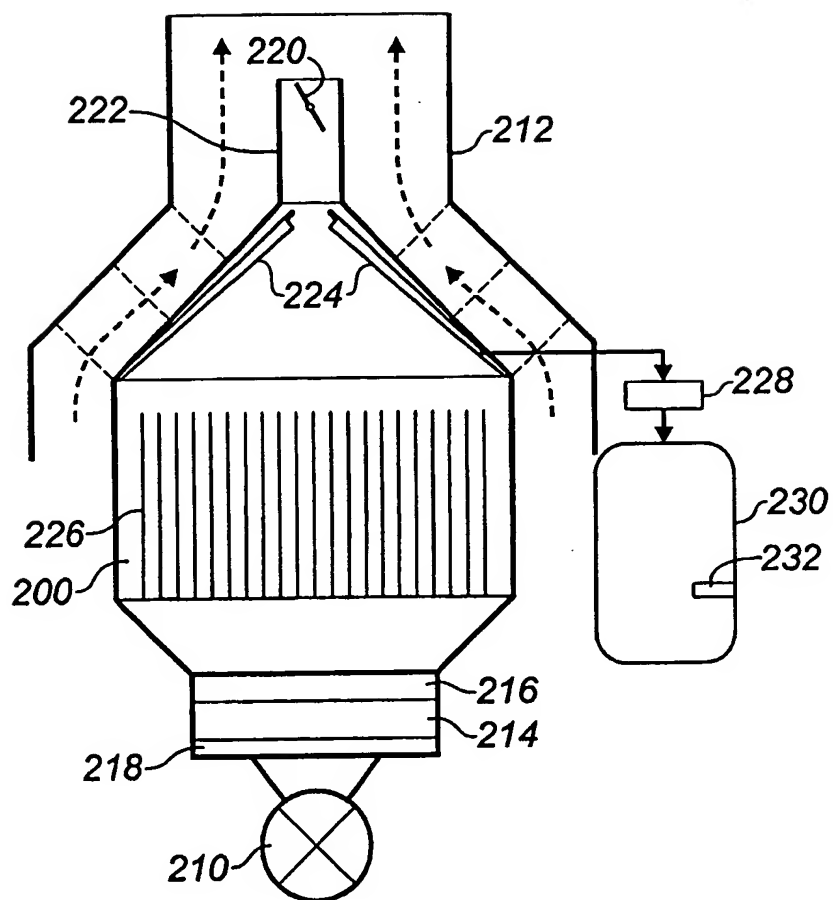


FIG. 1

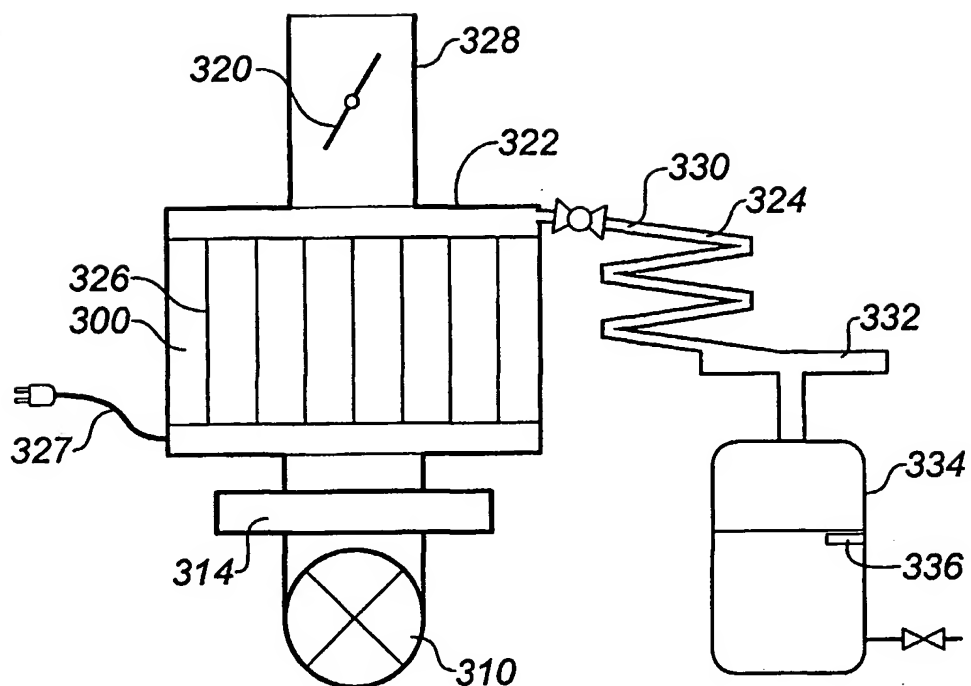
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FIG. 2

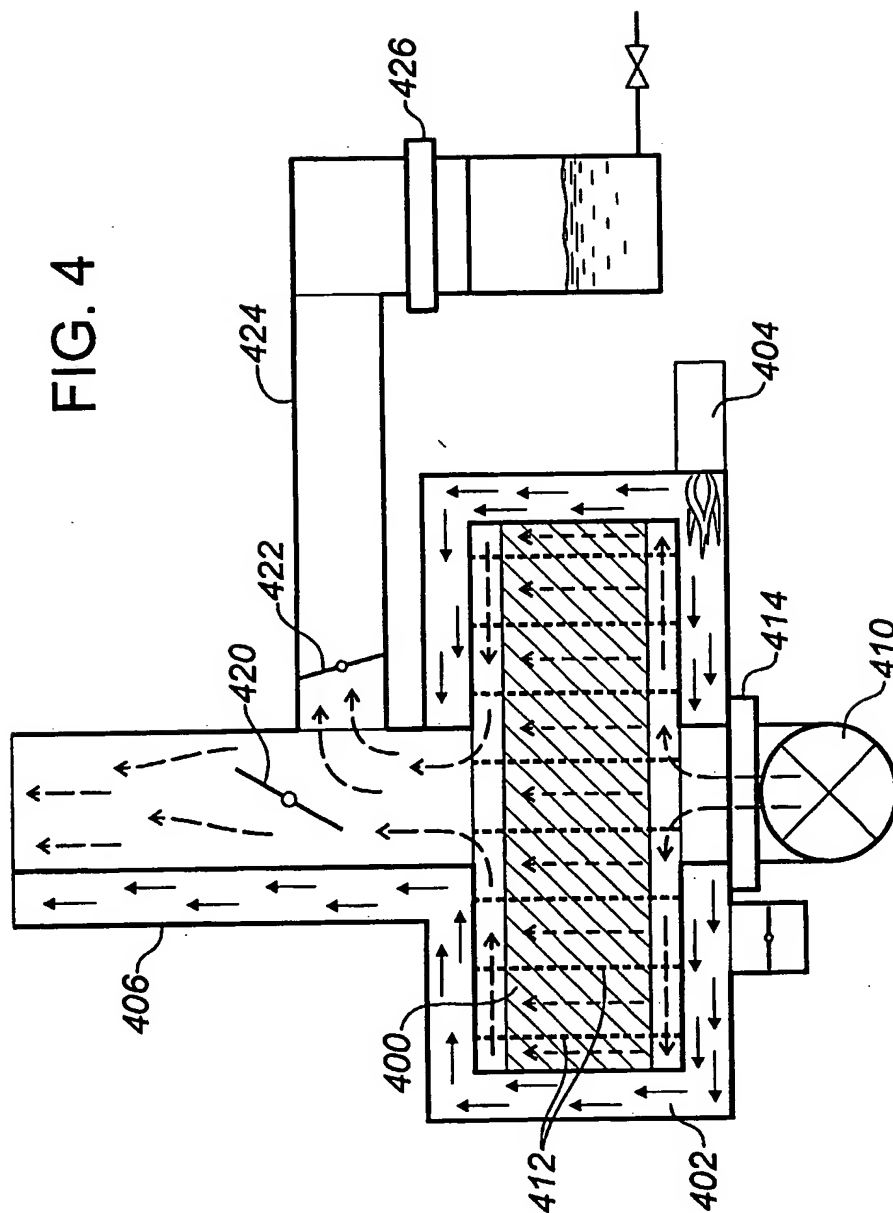


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FIG. 3

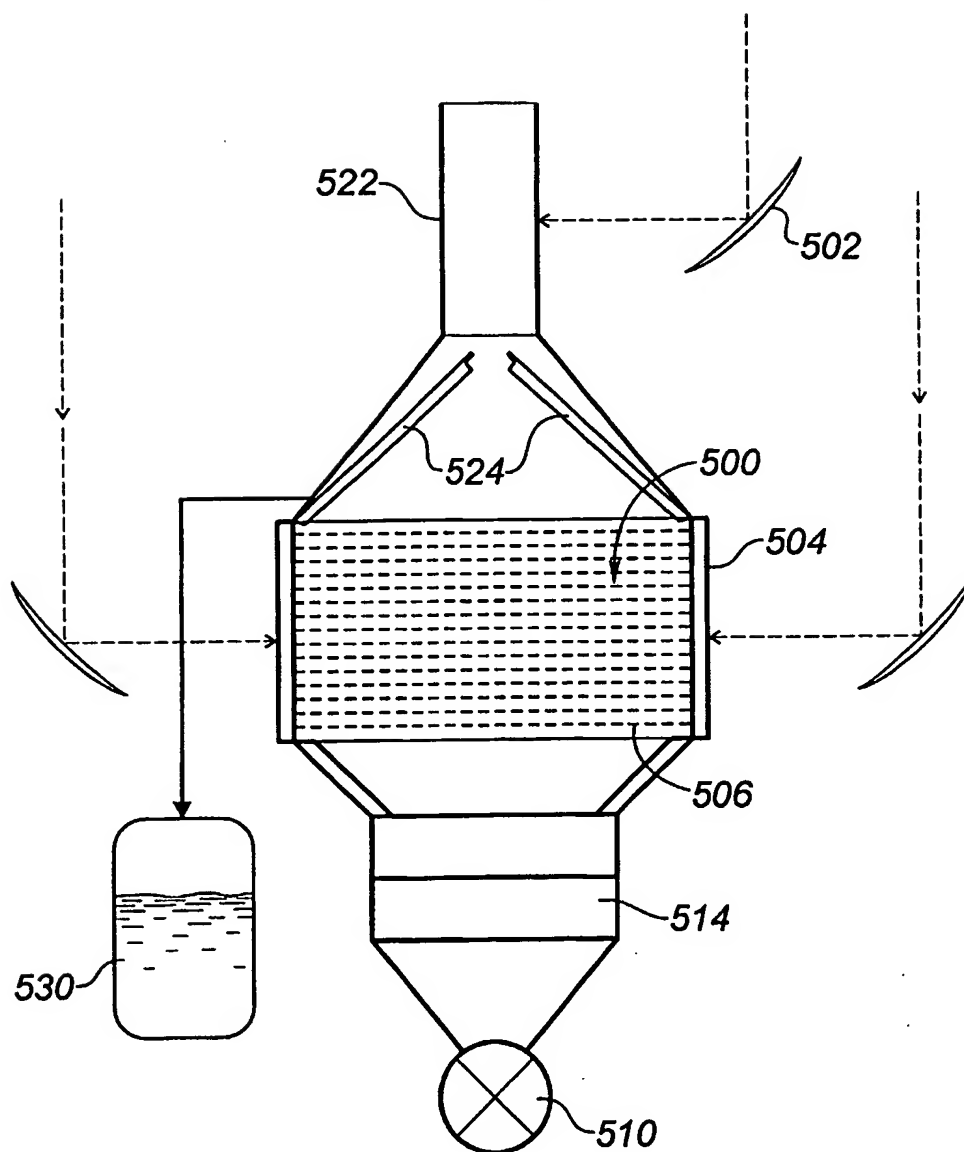


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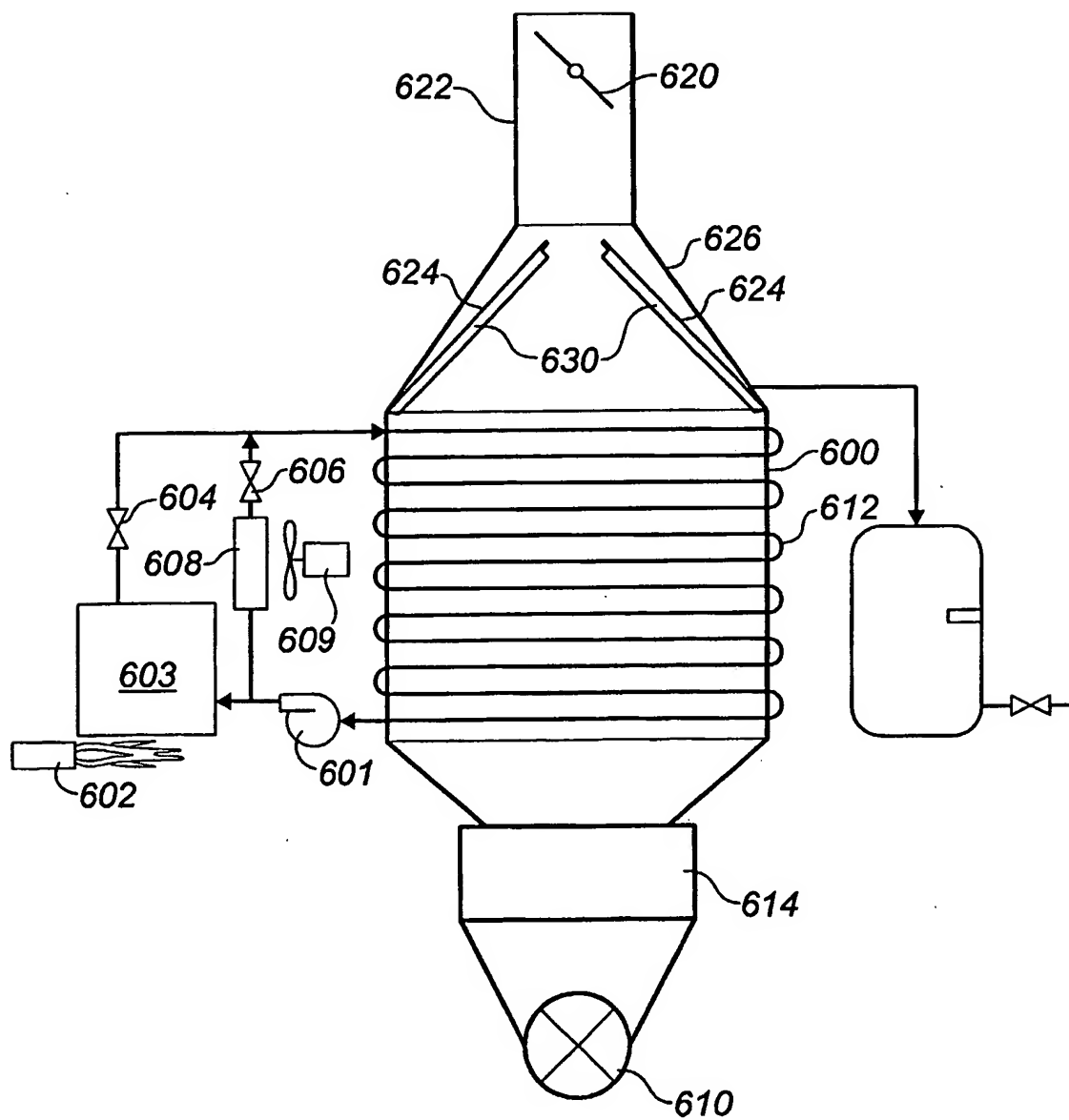
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FIG. 5



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FIG. 6



INTERNATIONAL SEARCH REPORT

In ☐ national Application No

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A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 E03B3/28 C02F1/28 C02F1/04 C02F1/78 C02F1/32

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 E03B C02F B01D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the International search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Patent family members are listed in annex.

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INTERNATIONAL SEARCH REPORT

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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